

EFFECT OF PROLONGED HYPOKINESIA ON CERTAIN FUNCTIONS
OF THE OTORHINOLARYNGOLOGICAL ORGANS

I. Ya. Yakovlev, V. P. Baranov, and E. I. Matsnev

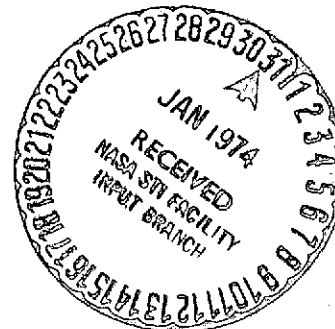
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16. Abstract The functional state of otorhinolaryngological organs was studied in six persons in restricted mobility for a period of 62 days. The occurrence of otorhinolaryngological morbidity was noted on the second month of restricted mobility (tonsillitis, catarrh of the upper respiratory tract, acute pharyngitis, nasal bleeding). The authors revealed circulatory disturbances in the nasal mucous membrane, increased dystrophy of the mucous membranes of the upper respiratory tract, reduced auditory sensitivity, and vestibulo-autonomic resistance. All the changes have an undulant dynamics and a period of sequelae. To a certain degree, they were caused by hemodynamic shifts and general asthenia.			
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EFFECT OF PROLONGED HYPOKINESIA ON CERTAIN FUNCTIONS
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I. Ya. Yakovlev, V. P. Baranov, and E. I. Matsnev,
Institute of Medico-Biological Problems, Moscow

Motor activity is an essential requirement for the existence /45*
of animals and man.

Study of human vital activity in conditions of partial immobility (hypokinesia) is not only of theoretical interest. This area is vital also for occupational pathology due to technical process.

The effect of relative hypokinesia on the functional state of the human organism was studied by a number of investigators (T. T. Dzhamgarov, 1961; Yu. V. Vanyushina, 1963; 1965; A. V. L. Myasnikov, 1963; L. I. Kakurin et al., 1963, 1966; N. A. Agadzhanyan et al., 1965; P. V. Buyanov et al., 1965; Deitrick, 1948; Gartman and Diringhoffen, 1952; Karpovich, 1953; Krause and Raabe, 1961; Lamb et al., 1964, 1965; Miller et al., 1964).

It was found that immobility leads to a decrease in human functional abilities and to deconditioning. Shifts were found in hemodynamics, the central nervous system, the muscular system, and so on. However, we found no studies explaining the effect of hypokinesia on the functions of the ORL [otorhinolaryngological organs in the literature available to us. There are a few indications of shifts in the vestibular function and hearing for relative hypokinesia and isolation (V. I. Kopanev, 1964; I. I. Tikhomirov, 1965; Ye. M. Yuganov et al., 1965; I. Ya. Yakovleva et al., 1966).

* Numbers in the margin indicate pagination in the foreign text.

Changes in the regulation of vascular tonus that are characteristic of hypokinesia evidently must also occur in the vessels of the ORL organs. The sensitivity of ORL organs to vascular disturbance has long been known. Symptoms of vasomotor rhinitis (L. B. Daynyak, 1962), labyrinthopathy (G. S. Tsimmerman, 1952), and disturbances in hearing (Ya. S. Temkin, 1957) can arise. Functions of the vestibular analyzer, besides hemodynamic shifts, can also reflect changes in afferent impulses from the musculo-articular apparatus. Accordingly, study of the functional state of the ORL organs in hypokinesia is of practical significance.

We investigated the functional state of ORL organs in prolonged hypokinesia (62 days) in six men aged 22 to 36.

Before the experiment, all the subjects were clinically examined as follows: seven persons were regarded as healthy; one had monolateral cochlear neuritis; another had anterior dry rhinitis and chronic pharyngitis, which is not a contraindication to hypokinesia.

According to the experimental program, all subjects were divided into two groups: the first group was the control, and the second group performed measured physical loads (work on a veloergometer [bicycle ergometer]).

The effect of hypokinesia was achieved by observing a strict bed regimen. The subjects were in a specially equipped room: artificial illumination, ambient temperature 18-22°, relative humidity in the limits 40-60% and normal atmospheric pressure.

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During the entire period of the study, the subjects were in the horizontal position. The position did not change during the periods of normal functions. Movements with the hands and rotation about the body axis were permitted. Sleep was nocturnal.

During the wakefulness period, they were allowed to read, listen to the radio, and write. The food was furnished four times a day, the diet was of the usual variety. Medical observation was taken round the clock.

This report presents data of examination made of the ORL organs.

The functional state of the ORL organs was evaluated based on interrogation data, ORL examination, and functional tests (audiometry, rhinopneumometry, the test for the cumulation of Coriolis accelerations [CUC], and rocking on Khilov swings.

Before and after the experiment, the audiometry included the threshold and suprathreshold tonal examination and determination of the curve of increasing speech intelligibility. During the experiment, a determination was made of the auditory thresholds for air conduction at frequencies in the range 125-10,000 Hz and auditory adaptation by the Hood method (1955) as modified by Carhart (1957). The studies were performed on an audiometer (Audiomatic -- Elza AUG-60).

Rhinopneumometry before and after the experiment was conducted in conjunction with changes in body position (a modification of the Rundkrantz test: I. Ya. Yakovleva and B. P. Baranova, 1966) and the duration of the recovery period with the transition to the vertical position was recorded. During the hypokinesia period, rhinopneumometry was carried out with the subjects in the horizontal position on their backs.

Audiometry and rhinopneumometry during the hypokinesia period were performed with an interval of 4-6 days. In the examination of hearing, data (Neuberger, 1963) on the smallest diurnal variation in auditory sensitivity from 11:00 am to 4:00 pm were taken into account.

Vestibulometry (before and after the experiment) included, besides the interrogation, an investigation using the Khilov swings and the tests for tolerance of cumulation of Coriolis accelerations (CAC) using the method of K. L. Khilov (1936) and I. I. Bryanov (1963).

All examinations of the lower organs in the recovery period after hypokinesia were repeated with an interval of 7-14 days until the functions became normalized.

During the hypokinesia period, inflammatory disturbances of the lower organs were observed in four persons: one had follicular angina (on the 41st day), two persons had acute pharyngitis (on the 33rd and 47th day), and one had aggravation of chronic pharyngitis (on the 37th day). Dryness of the nasal mucosa increased in the last-named subject, suffering from anterior dry rhinitis, but when he underwent rhinoscopy, swelling of the inferior nasal sinuses, severe dryness of the mucosa, lesions, and dry crusts in the anterior nasal divisions were observed. Nasal hemorrhages occurred twice during the experiment. After ointment applications were used, the dryness of the mucosa decreased, and the hemorrhages stopped. No pronounced dryness of the mucosa of the upper respiratory passages was noted in the remaining subjects. I. I. Tikhomirov (1965) also reported dryness of the mucosa of the upper respiratory passages during hypokinesia. Nasal hemorrhages developed in four persons during this period. The background condition of the lower organs unfortunately is not presented for them.

Evidently, hypokinesia, by causing functional changes in hemodynamics and neural regulation, can promote a rise in dystrophy. An increase in the dystrophy of the mucosa of the upper passages can lead to nasal hemorrhages.

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The examinations made revealed changes in blood supply in the nasal cavity in all subjects. This was expressed, subjectively, in nasal stuffiness that was felt more in the left nostril, as a rule. The disturbance of nasal respiration was not accompanied by any signs of rhinitis. Rhinoscopy showed swelling of the lower nasal sinuses, somewhat more pronounced in the posterior divisions; and the mucosa showed moderately pronounced bluish coloring.

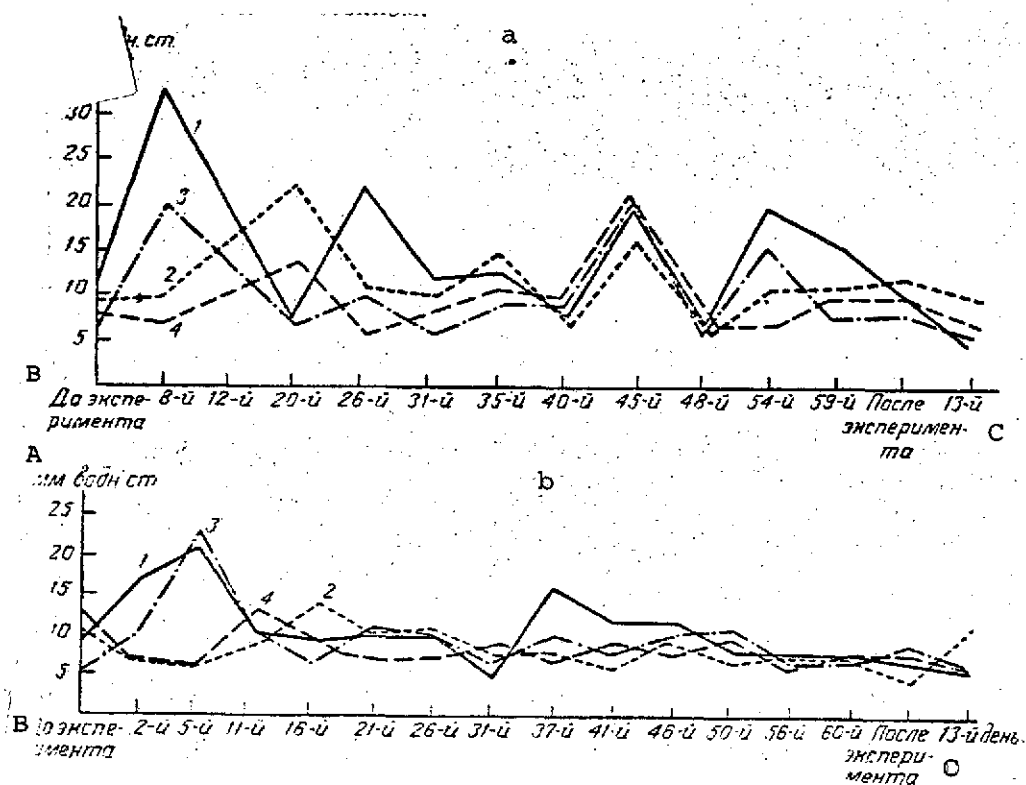


Fig. 1. Dynamics of intranasal drag during the experimental period. a. Subject S (from the group receiving no physical load); b. Subject V (from the group receiving physical load); 1. expiration through right nostril; 2. expiration through left nostril; 3. inspiration through right nostril; 4. inspiration through left nostril; the days before and after the experiment are plotted on the X axis; the pressure in millimeters of H₂O are plotted along the Y axis.

Key: A. mm H₂O C. After experiment
B. Before experiment

In rhinopneumometry, an increase in intranasal drag was noted, indicating an increase in blood flow in the nasal mucosa. These changes were recorded on the fifth, eighth, and tenth day of the experiment. The indicators of rhinopneumometry reached 20-35 mm H₂O. Some decrease and relative stabilization of the intranasal drag values were established, with some rises in this indicator in the form of peaks. In subjects not performing physical exercises (first group), these peaks were 22-50 mm H₂O, and in the second group -- 18-25 mm H₂O. In the first group the plot of the dynamics of the rhinopneumometry data had not only greater increases, but also more peaks.

Repeated rises were noted oftener in the second half of the experiment (34th, 45th, and 57th days). Sometimes the increase in intranasal drag was greater than at the beginning of the experiment. A distinct asymmetry of the indicators for the right and left nasal halves was noted in a number of the subjects. Evidently, it was associated with the nasal characteristics of the individual subjects (sleep predominantly on the left and right sides).

The dynamics of the rhinopneumometry data during the experimental period is shown in Fig. 1 for two subjects of the different groups.

A comparison of the rhinopneumometry data before and after the experiment showed an increase in the lability of vascular tonus after hypokinesia. The reaction of the nasal vascular system to change in body position after hypokinesia was more strongly pronounced, especially in subjects with no physical loads (Fig. 2). Evidently, systematic physical load during the hypokinesia period promoted maintenance of relative stability of peripheral vascular tonus. The recovery period in the first group was longer (up to 13 days), while in the second group it was 1-2 days. There were no

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complaints concerning the ears during the hypokinesia period, and no otoscopic changes were found.

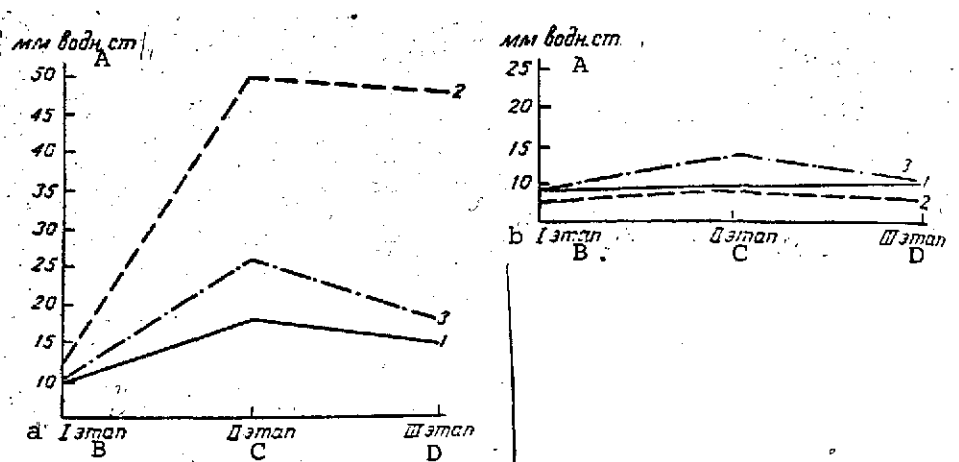


Fig. 2. Dynamics of intranasal drag with change in body position (before and after the experiment):
a. subject S (from the group without physical load);
b. subject M (from the group with physical load);
1. before the experiment; 2. on the first day after the experiment; 3. on the 13th day after the experiment.

Key: A. mm H₂O
B. stage I
C. stage II
D. stage III

Studies made of hearing showed that a two-month exposure in conditions of restricted mobility causes transitory functional disturbances in the auditory analyzer, which was manifested in an increase in tonal thresholds.

Variations in the threshold sensitivity (from 15 to 34 db) were noted in all subjects; the audibility thresholds increased mainly for high frequencies (2000-8000 Hz) and exceeded the mean dispersion values of auditory thresholds for a healthy person (Carpendale, 1952; Egan, 1954; B. Ye. Sheyvekhman, 1956, and others). Audibility thresholds immediately after the experiment were restored in four subjects, and after 2 weeks -- in two subjects.

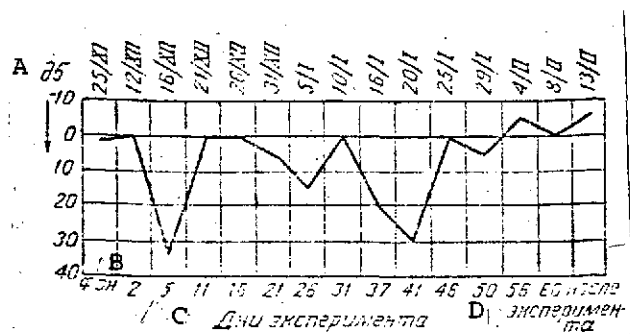


Fig. 3. Dynamics of thresholds of auditory sensitivity for air transmission at the frequency 6000 Hz (subject G).

Key: A. db; B. Background; C. Days of the experiment; D. After the experiment

The highest rise in the audibility threshold (from 34 to [illegible]) occurred at 6000 Hz, which is shown in Fig. 3.

The maximum rise in audibility thresholds occurred on the fifth and eleventh days of the experiment. Some adaptation set in by the end of the experiment: the audibility thresholds were reduced to values corresponding to the dispersion limit of auditory thresholds in the normal state.

It must be noted that we observed an increase in the audibility thresholds only on the side of the affected ear for subjects S with right-sided cochlear neuritis, during the experiment (Fig. 4). It can be assumed that the affected ear proved less resistant to the unfavorable factors of this experiment.

The disturbances in the threshold adaptation during the experiment and after it had been concluded did not exceed the dispersion values for this indicator in the normal state. Data of speech audiometry and suprathreshold studies after the experiment were unchanged. /49

We were unable to establish any differences in the auditory sensitivity in control-group subjects and in those receiving physical loads.

The question of the mechanisms underlying auditory disturbances related to hypokinesia requires special study. Our investigations revealed apparently two periods of maximum shifts

(5th-8th and 41st-45th days of the experiment). According to literature data, the greatest changes in hemodynamics were noted on the 4th-8th day of hypokinesia (P.B. Buyanov et al, 1966). Evidently, changes in blood circulation in the cochlea caused a rise in the auditory thresholds at the beginning of the experiment. This hypothesis is confirmed by the greatest vulnerability of high tone perception, which is usually characteristic of disturbances in blood circulation in the cochlea (G. S. Tsimmerman, 1952; Ya. S. Temkin, 1957, and others).

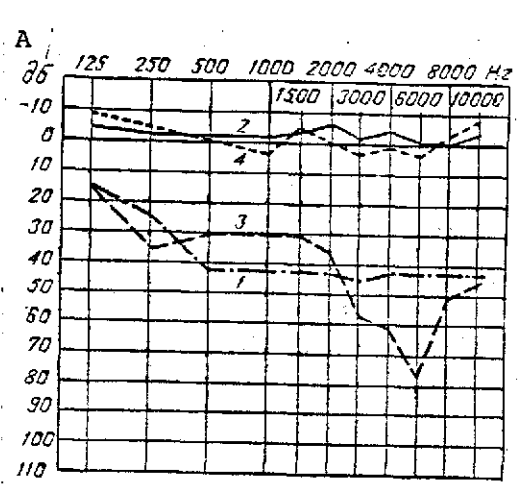


Fig. 4. Auditory sensitivity for air conduction before and after the experiment (subject S): 1. right ear, before the experiment; 2. left ear, before the experiment; 3. right ear, after the experiment; 4. left ear, after the experiment.

Key: A. decibels

Disturbance in hearing in the second half of the experiment may have been caused by general asthenia of the subjects, noted in the neurological and psychiatric examination.

There were no complaints of vestibular disturbances during the experimental period. Before the experiment, the vestibulo-autonomic resistance, when examined on Khilov swings, was good for all subjects. All tolerated 15-minute rocking without reactions to changes in the rocking rhythm, without symptoms of discomfort, and with moderate fluctuations in pulse

rate (from 2 to 8 beats per minute). Vestibulo-autonomic reactions (VA) were of the 0 degree (according to the K. L. Khilov classification). Background studies showed excellent tolerance of the CUC test only in two persons (15 minutes with 0-degree VA); four persons tolerated this test for 3-5 minutes with VA of degree I-II. Subjects with excellent and reduced

vestibulo-autonomic resistance based on data of the CUC test were uniformly distributed among both groups.

After the experiment, deterioration in the indicators of tolerance to vestibular tests was noted in all subjects. For example, in the first group the indicators were poorer in two persons tested on the Khilov swings, and remained unchanged in one; in the second group, these indicators were poorer in one person, and unchanged in two. The tests for cumulation of Coriolis accelerations revealed deterioration of indicators in both groups (in three persons in group 1 and in three persons in group 2).

The investigation with the Khilov swings, given the deterioration in the vestibulo-autonomic resistance, was accompanied by VA of degree I-II by the 10th, 13th, and 15th minutes.

During rocking, the manifestation of hyperhydrosis, changes in skin color (most often, blanching), and sensations of discomfort and nausea were noted. Reaction to changes in rocking rhythm was noted in individual subjects. A distinct tendency of pulse acceleration was noted in four persons (from 10 to 20 750 beats per minute). On the 13th day after the experiment, the function was restored: all subjects tolerated rocking for 15 min with a 0-degree VA. Tolerance of the test for the cumulation of Coriolis accelerations after the experiment also deteriorated in all subjects. Two who had excellent initial tolerance for the test were able to tolerate it for 3 and 7 minutes with degree I-II VA after the experiment. In the remaining four subjects, test tolerance was 1-2 minutes shorter.

Autonomic reactions in the CUC test after hypokinesia were more distinctly pronounced; paleness of skin, hyperhydrosis, nausea, heaviness in the area of the stomach and a tendency to vomit were observed. Changes in pulse rate in this test were

less well pronounced. The tendency to tachycardia was noted in three subjects (a quickening in the pulse rate from 8 to 16 beats per minute). Recovery of tolerance for this test occurred slower than for swing rocking and varied for individual subjects.

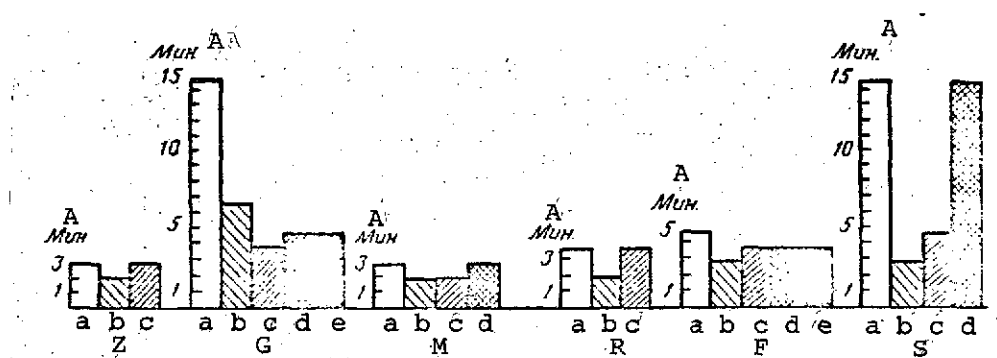


Fig. 5. Dynamics of tolerance of cumulation of Coriolis accelerations before and after experiment for a number of subjects: a. before the experiment; after the experiment: b. on the second day; c. on the 14th day; c. on the 55th day; d. on the 75th day.

Key: A. Minutes

Recovery of initial data for the CUC test occurred in only two persons from the different groups when a control examination was made on the 14th day after the experiment. Subject G showed even a poorer tolerance for the test by this time compared with the data obtained immediately after the experiment (down from 7 to 4 minutes). The recovery occurred on the 55th day in two subjects. Over 2.5 months of observations, no recovery of test tolerance to the initial level occurred in two persons, and the sensitivity to the CUC test in these subjects was relatively stabilized at a new low level. Subject F tolerated the test for 4 minutes when investigated three times over a span of 2 months, while subject G tolerated it for 5 minutes under the same conditions. The dynamics of tolerance for the test for the cumulation of Coriolis accelerations before and after the experiment is shown in Fig. 5.

These studies showed that independently of the initial background, restriction of mobility causes a decrease in vestibulo-autonomic resistance, especially to Coriolis accelerations. Changes in the functional state of the vestibular system to some extent reflect the general deconditioning of the organism noted after hypokinesia (P. B. Buyanov et al., 1966). Also in agreement with this finding is the lower degree of vestibulo-autonomic reactions in tests made on persons performing physical loads during the hypokinesia period.

Conclusions

1. Restriction of mobility and relative isolation for 2 months in generally healthy persons causes a number of functional disturbances.

2. Changes in lower organs are characterized by disturbance of blood circulation in the nasal mucosa, reduction in auditory sensitivity, and reduction in vestibulo-autonomic resistance exhibited undulant dynamics and a period of sequelae. The factor of asthenia is significant for these changes, to some extent caused by general hemodynamic shifts. /51

3. Disturbances in intranasal blood circulation were in the form of congestive symptoms in the inferior nasal sinuses and lability of their vascular tonus; greater intensity of these disturbances was noted in the group without physical exercises.

4. Fluctuations in the auditory thresholds during the hypokinesia period amounted to 15-34 db, mainly at high frequencies, and were the same in both groups. When cochlear neuritis was present, hearing was found to be less resistant to hypokinetic factors.

5. The decrease in vestibulo-autonomic resistance after hypokinesia was differentiated in character, and the tolerance to cumulation of Coriolis accelerations was disturbed for a longer time compared with tolerance to the cumulation of linear accelerations. Vestibular disturbances were more well-defined in the group of subjects not performing physical exercises.

6. Hypokinesia promoted an increase in the dystrophy of the mucosa of the upper respiratory passages and reduced resistance of the organism, which possibly also was responsible for the development and aggravation of pathological processes in the ORL organs.

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